Observations on the Scientific and Political Aspects of Pollution and its Control[1]

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ABSTRACT

The scientist faces several challenges in discharging his responsibilities in this age of environmental consciousness. He faces them in a society that is skeptical of his motives and dubious of his sincerity. But he will solve our current environmental problems and avoid creating others by becoming even more sensitive than he has been to the need to fit his new technology more comfortably into the environment. In doing so, he will help restore science to the position of respect it once enjoyed, and will help clarify in the public mind the difference between the role of the scientist and the role of the politician in coping with such controversial matters.

These observations, and observations are all they are, are bound to be less microbiological than they will be something else. It's likely, on the scientific side, that they'll tend to be mostly chemical. Not that we don't have microbiological pollution problems, but the principal pollutants that the public is now hysterical and even nasty about are largely chemical: gases and particulate matter from factory and power plant stacks and from exhaust pipes, non-biodegradable plastics and detergents, solid wastes and dirty water from food and clothing processing plants, oil spills, pesticides, fertilizers. These scientific observations will be seasoned with some non-scientific ones—we'll call them political—because the control of pollution we seek will be instigated and policed by the Federal and State regulatory agencies, which, while operated mainly by scientists down under in these organizations, follow the directives, and sometimes the whims, of Congress and State legislatures.

In any event, the subject we've been invited to discuss is a series of problems that affects all of us and will for some time to come. As scientists, we are particularly concerned because they are problems no matter which way we look at them—one might say they are spherical problems. Our work in the laboratory has helped create most of the technology that is being over-used or misused to foul the public nest. As scientists, we are being expected to quit inventing new things that add to these problems and to devote our efforts, instead, to finding ways to correct the damage we've created and, at the same time, help solve problems that we've had little hand in creating. Again as scientists, and by virtue of our roles in the policy-making or rule-making processes in our society, we have our biases, borne of the multiple impinging factors in the particular world in which we operate. And inciden-

[1] An address delivered to a meeting of the American Society for Microbiology, Washington Branch, Georgetown University, Washington, D.C., October , 1971.

tally, so do the teachers, the legislators, the lawyers, the Federal and State regulatory officials and the conservationists. As citizens, we are concerned about ourselves, our families, our pets, our gardens, our hobbies, and generally about the cleanness of our surroundings. And in this role we tend, just like other citizens, to be biased, opinionated and narrow-minded concerning the things we know least about.

So we'll touch on some of the things I believe are pertinent—you could possibly call them my personal, narrow- minded views—as we seek sane ways of coping with the pollution problem. I make no claim to being an expert, except to the extent that a biochemist appearing before a predominantly microbiological group might be called an expert of sorts. He might be expected, however, to bring a different viewpoint to the subject—exposure to different viewpoints is supposed to be a good idea, particularly if you don't agree with them. Such sessions as this are not likely to lead to sudden solutions. But from sessions like this can come ideas that each of us can use to guide our actions in our own world and thus move in directions that have a reasonable chance of resulting in prompt, sensible solutions of some of our environmental problems.

The topics in the title are not easily separable, but let's take a look first at the science of some of our problems, than at the politics, than at the interface between them, and finally, at what we as scientists can do more of or do better.

Pollution begins with, and really ends with, people. Generally, people are both the main contributors and the loudest complainers among those upon which pollution is inflicted. Ian McHarg, author of the remarkable book, "Design With Nature," regards people as the earth's principal pollutant[2]. Some ecologists would agree. But we have a problem in 1971, not because people are a great deal dirtier than they used to be, but because there are so many more of us.

[2]Ian McHarg, Professor of Landscape Architecture and Regional Planning, University of Pennsylvania, "Man – Planetary Disease?" in Catalyst for the Environmental Quality, Vol. II, No. 1, p. 13, 1971.

On June 1, 1900, the population of th U.S. was nearly 76 million. On November 1970, after three score and ten years ha passed, the population of this country wa over 206 million. In the Biblical span of on man's lifetime, the U.S. had increased i population by 130 millon people, approx mately the total number of people in th country in 1940.

More people require more food and clot ing, and this in turn necessitates the produ tion of more of the traditional pollutants c agriculture and the food and fiber processin industries. More people drive more autom biles, and this multiplies the burden of ex hausts in the atmosphere and of junked ca on the landscape. More people require mor heat in winter, more cool in summer, an more electric power to run the "must" gad gets that Madison Avenue encourages us t have, and this increases the demands upo air, earth and water to absorb the by products thereof. More people flock to citie where the jobs are and the action is, concer trating all of these pollution problems i smaller areas where they become more ob vious.

Without a workable system of populatio control, or a change in "values" as some o our youth insist, this is and will be our wa of life for quite a while. So we are in a situa tion, to look at it whimsically, where we'l be living in a world described fairly accurate ly and sequentially by a list of alliterative "P's": People, Pollution, Problems, Perplex ity, Palaver, Propaganda, Penance and Pa tience. And, of course, there's always Poli tics.

What is the stance of science right now As we've said, we scientists, or our gifted naturalist or inventor predecessors, are re sponsible for making possible most of the things we have today. The tanner of hides established his plant next to a stream and dumped his wastes in it. So did the dairy and cheese plant, the cannery and paper mill Some mills burned their wastes or buried them. When living was less cramped, dilution and the natural purification processes o streams, soil and the atmosphere did not al low the pollution problems to surface, but ome were there. Now, with the demand for more and more product, the dilution effect less, the streams and atmosphere are overtaxed, and smog and the news reports of dire consequences and hidden hazards make people daily aware of and nervous about the same old pollutants. To these we add, of course, the newer pollutants, many not biodegradable, that technology has more recently developed—the pesticides, detergents, plastics, and others.

This means that the scientist is confronted with a several-sided challenge: (1) to find less-polluting ways to do and make the same things; (2) to better understand the effects of pollutants on animal and plant life; (3) to find practical means, and these may well be microbiological, for ridding the environment of pollutants already present; and to (4) develop methods to measure the minute amounts of the smorgasbord of pollutants that are the present bones of contention, with the precision and speed necessary to permit prompt and proper action by regulatory bodies to protect people and the rest of the environment. Let's discuss one or two of these challenges; first, measurement.

Everyone knows that present, sophisticated methodology permits us to measure vanishingly small amounts of almost anything. One of the reasons we have developed these methods, of course, is that we've had to. We must measure accurately to parts per billion (or micrograms per kilogram, if we are to go metric with the rest of the world), or even less in some cases. Given the time for the care that must be exercised, and assuming there is no need to concern oneself about expense, this is possible, even if usually difficult. Interferences must be taken into account—closely related substances sometimes masquerade as the real thing in analytical tests; tissue fluids or other extraneous materials concomitantly present may mask or potentiate the result. So it often takes time and pains and a lot of expensive, sometimes immobile, equipment to do the job while the world waits impatiently for results. And we haven't even mentioned the problems of drawing a representative sample for analysis, say from a box-car of peanuts, or from several thousand cans of vichysoisse, or from the waters of a large tidal estuary. So the scientist is feverishly striving for quicker, simpler, more positive, and cheaper analytical and sampling methods on all fronts.

Let me cite a few examples that are of concern to scientists in agriculture and other disciplines.

Relatively recent FDA action in removing from the market swordfish found to contain more than 0.5 ppm of mercury made the public aware of possible widespread mercury contamination of marine products. Fortunately, methodology for determining mercury at trace levels exists, so it has been feasible to expand greatly and quickly the monitoring of commercial fish for its mercury content. The method now in general use involves chemical oxidation, then reduction, and the measurement of the mercury by atomic absorption. A determination requires only a few minutes. But needed in these times, is a procedure—perhaps this one—that can be automated for similar samples in which the mercury content does not vary more than 10-fold. It would also be desirable to have a method which could be used to continuously monitor the mercury content of a water supply or effluent wastes, with the possibility of using the output as a feedback to automatically control the operation of a mercury decontamination device, which, incidentally, also needs to be invented. Another useful development would be portable equipment which could be used in the field or on a boat for monitoring mercury and other toxic elements such as lead, cadmium, and arsenic in water supplies and in food.

There is an old but growing need to assess and control microbial growth in food products in order to conserve them and provide wholesome, safe food supplies with adequate shelf life. Presently used methods of estimating total viable bacteria involve culturing and counting which are laborious and time-consuming operations. As a result, the testing of products is sometimes unduly delayed, or the products move through channels of processing and distribution without a current record of their bacterial load. You know better than I that attempts to develop alternative chemical methods have fallen short of the ideal. A workable method should be general enough to react to and measure all viable microorganisms and yet be specific enough to exclude all dead cells and foreign organic matter. This is a most difficult goal for the analytical researcher and is likely to involve a basic search for suitable transient intermediary metabolites to serve as the reactive chemical indicator of total viable bacteria present.

A more specific microbiological problem concerns *Salmonella* methodology. Standard cultural and serological techniques for the identification of *Salmonella* require some 4 days, and the methods are rather complex. More rapid and reliable methods are needed, particularly for the assessment of sanitation in food processing plants and for official inspection of products. Improvements are being made which reduce the time required for identification of *Salmonella* by about one-fourth, but a still more rapid procedure is needed to meet monitoring requirements in food processing and inspection operations.

While we're still close to the field of microbiology, we should mention a group of microbial metabolites—the mycotoxins—which were recognized to exist and to be important within the last decade. The demonstration that aflatoxin, the first-to-be-discovered toxic metabolite of *Aspergillus flavus*, is potently carcinogenic, triggered a vast amount of research to determine the extent of the aflatoxin problem and to study other microorganisms for similar metabolites. Accurate and sensitive analytical methods exist for the aflatoxins, depending on thin layer chromatography and the automated evaluation of the TLC plates by fluorodensitometry. But these methods require moving the sample to the laboratory with attendant delays. Needed is a more rapid method for detection of aflatoxin in the field to avoid delays in moving commodities. Success in developing such a method is of obvious importance to agriculture and the food industry.

As a final example I'll mention polychlorinated biphenyls (PCB'S), which have received much notoriety lately. The PCB'S are extensively incorporated into asphalts, rubber tires, paints, plastics, and a variety of other products. As a result, they have entered the air, water, and soil through industrial and garbage smoke and through accidents. These compounds are similar in many respects to DDT and are important sources of interference in the chemical detection and measurement of chlorinated hydrocarbon pesticides. Methodology is presently inadequate for the separation of the PCB'S from other chlorinated hydrocarbons and for the characterization of each. Pure samples of the PCB'S and the polychlorinated triphenyls are needed. Moreover, the very complex nature of the gaschromatographic patterns (the method currently used) requires better systems to differentiate between compounds. The PCB'S are examples of industrial products that can lead to residue problems in agricultural products. The problem requires prompt attention.

Now, how about the responsibility of the scientist to get a better understanding of the effects of trace pollutants on animal and plant life? This is probably the most crucial of the several controversial areas in the overall problem. How many tests and on what and for how long and at what dosage need be done before we can say a certain level of something in food, air, water, or next to the skin, is safe?

Basic to the resolution of these controversial issues is knowledge, now lacking. We do not know, for example, what the long-term effects of trace amounts of most of these chemicals will be on man, nor do we know what their ultimate fate will be in soil, water and other parts of the ecosystem. Crucial to the resolution of questions of environmental pollution, is the establishment of the significance in man of the results of toxicological experiments on laboratory animals. We need to have settled, among other things, some questions concerning cancer and carcinogens, teratogenicity and teratogens, species specificity, significance of dose size and route, and the effect of substances to which the living animal is concomitantly exposed. We need knowledge to enable us to cut through the present apparent complexities and arrive at an acceptable practical answer to the question, "How safe is safe enough?"

This is far from an academic question, but it is one that must be faced repeatedly in administering programs for regulating the use of chemicals, whether they be pesticides, drugs, or food additives. These decisions, based on scientific knowledge, must be made in the light of what is best for the overall welfare of man, his environment, and the creatures with whom he chooses to share the environment.

In the toxicological area, particularly, misinterpretation and disagreement as to the proper interpretation of experimental results, often honest but often heated, is now commonplace. The last chapters are yet to be written and until they are, we will continue to have controversy. Meantime, it is wrong either to treat these important matters superciliously or to get overheated about them. This advice is to scientists, at least, and to others who should also know better.

A word should be said about alternative ways to do the things we are now doing or about inventing new things. Such changes are most likely to come from industry, based of course, on the research of many including their own. It's true that there always tends to be a certain amount of industrial myopia, but an industry's repute in its field and the success of its business depends on satisfied customers—satisfied that a product will do what the label says it will and that use of the product will not hurt them. A coming-to-terms on the safety tests required on new pesticides, disinfectants, drugs, and other chemicals is important to them. Competition being what it is, there is a limit to how much time, hence money, can be invested in product testing, before it becomes uneconomic to pursue a product's development. So let's not be too hard or unreasonable with industry. If they should abdicate, who, then will develop the new or better or needed products? With 1 of every 6 Americans on a public payroll already (David Brinkley. September newscast), is it reasonable to project this as another public responsibility? I would think not.

A word should also be said here about University scientists and their role as teachers rather than as researchers. A start has been made in several places to try to educate students who are not going to be scientists, but who will assume influential positions in the decision-making world, in some of the important precepts and limitations of science. This should continue and multiply so that more of our future economists, lawyers, judges, Congressmen, medical practitioners and laymen generally have a better conception of the experimental method and of the significance that can be placed, or cannot be placed, on isolated results; of the difference between what the scientist knows as truth and the half-truths with which so many seem now to be content.

All of these things the scientist has to do, or help do, or adjust himself to, in the current atmosphere of dwindling prestige of men of science. The 40 "golden years" of science just passed, through which some of us have lived and worked, have given way to a public skepticism of science. And this, unfortunately, is being nurtured by some important people who have access to the public ear. The credibility of scientists is being questioned, and it is public policy that research and the new knowledge it creates is not among the top 3 or 4 things that they say we need most now to spend our money for. Scientists, generally, don't agree, but we will persevere (the hard core of us, that is) because we are brought up to be convinced that lasting solutions of most of our problems will depend on the knowledge that the trained researcher can develop. All, eventually, come to recognize this, if not to admit it.

This has been said better by Dr. Harvey Brooks, Dean of the Division of Engineering and Applied Physics, Harvard University, and one of the President's top science advisors about 10 years ago, in his C.P. Snow Lecture at Ithaca College in January, 1971. Speaking to the topic, "Can Science Survive in the Modern Age?," he concludes: "I cannot give a definite answer one way or the other. The threats to the integrity of science, both from within and without, are probably greater than at any time in the past, because science is much more a part of the total social and political process, no longer the semi-hobby of a few dedicated and somewhat eccentric individuals. But I am an optimist. I do not think that the scientific enterprise is going down the drain. It will change as science has always changed. It will respond to new social priorities, but, like an organism responding to disease, it will develop antibodies which will fight and finally contain excessive control by external criteria, and in fact will transform these external pressures into new opportunities and new fundamental fields of inquiry."

This leads us to consideration of some of the political aspects of our topic, if indeed we may not already be well into consideration of them.

When science, or anything else that's important, becomes controversial–becomes an issue–politics enters. Pollution has become an issue, and politicians have stepped in, as of course they must, to try to find practical, sometimes stop-gap and sometimes complete resolutions of the things in controversy; to arrive at a tolerable balance between the pluses and minuses of each issue; and through the political technique of exaggerating hazards and consequences, encourage the public to support new laws and regulatory actions.

The politician moves from a position of shallow knowledge and understanding of the science of the problems he grapples with. This is not intended to be critical. Science is not everybody's cup of tea and many politicians try very hard, through advisors, hearings and the like, to smarten themselves up. But more generally they are influenced less by the scientific facts of a matter than they are by public fears and emotions and the statistics that presume to reflect them. The prototype politician sees nothing wrong in settling a controversial issue by taking a vote on it. To illustrate, let me quote from the September, 1971 speech before the American Chemical Society, of Mr. William D. Ruckelshaus, a lawyer and President Nixon's political appointee to head the new Environmental Protection Agency: "Decisions such as the fate of DDT are not decisions solely within the purview of the scientist to make in his laboratory. Rather they are basic societal decisions about what kind of a life people want and about what risks they are willing to accept to achieve it ....I fully understand the scientist's desire to seek a quiet spot to contemplate and carefully work out rational solutions, as well as his distaste of the hysteria that sometimes accompanies public discussion of environmental issues. However, the demands of a free and open society will not permit such a luxury." Many scientists would be reluctant to accept this kind of settlement of some pollution issues as being any real settlement at all. I like better in this respect a quotation from Milton Burton[3]: "In this technological age, ignorance of science can be dangerous. It is inexcusable in those who have talents of leadership. It is immoral when the ignorant elect to lead and when the informed let them. There must be clear and positive rejection by honest scientists of the domination of decision by those who are unequipped to make rational, honest decision. There must be an actual act of struggle on the part of scientists to see to it that those who make decisions have had the opportunity to learn enough of science either to make adequate decision themselves or to accept guidance in decision by scientists equipped to advise them in this particular time of expanding technology."

There's another contrast between the scientist and the politician that is relavant. The scientist is attuned to working and waiting for decades, if need be, to come to the solution of a problem. Politicians, often, can wait only until time for the next election. As a result, scientists are being hurried, and are expected to move even faster, and this is irksome to many. But, I might add parenthetically, scientists had better get used to being hurried and used to working on phases of problems in which they have less than an abiding interest if they are to contribute at all to their solution. Otherwise, the politicians, with the public behind them, are going

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[3]Milton Burton, Emeritus Professor of Chemistry, Radiation Laboratory. University of Notre Dame; in Chemical and Engineering News, September 27, 1971, p. 1.

to "solve" them even without the scientist's help. Those scientists with a long future ahead of them would do will to heed this for the time being, else the havoc created by premature and primarily political "solutions" of these problems will require the scientists of the future to be trouble-shooters for many years rather than the creators most prefer and are trained to be.

There are some things, I believe, that the politicians are equipped to debate and solve while the scientists are solving the technical problems concerned with pollution. There are some questions that need answers and in ones like the following, views of the public would be relevant and significant:

Should scientists, particularly industrial scientists, advocate and defend new technology and let the public and other pressures bring problems that it may create to them, or should scientists have the responsibility of anticipating and solving in advance the environmental problems their new technology may create?

What should the role of the courts be with respect to the environment? Should we try to resolve complex technological problems by adjudication rather than by administrative determination based on judgment of experts?

What should the role of Congress and State legislatures be with respect to the environment? Should we try to resolve complex technological problems by legislation?

Is a "truth squad" approach, where competent scientists winnow the conflicting views concerning environmental problems and make public an informed judgment, a practical means for public enlightenment and guidance?

How necessary is control of population growth to the ultimate alleviation of our environmental problems?

Scientists could and should, of course, help the politicians in getting answers to these questions and the answers, in turn, would help scientists in directing their future attitudes and actions.

Now, finally, I'd like to share with you some personal views on how scientists should behave at the interface between science and politics.

I'm convinced of one thing, principally. The scientist should stick to being a scientist and play that game according to the rules of science. By so doing, he'll retain the respect of other scientists and eventually regain the respect of society. It is my observation that scientists who try to play the game of politics are generally inept, although they seem to be the last to know. The scientist-become-politician, and these are mostly in government, has usually started too late to be taken seriously by the public or by professional politicians. He also has a basic conflict. His scientific upbringing, the practice of proceeding from hypothesis, to theory, to test, and to proof, is a handicap in the political arena, because the steps follow each other too slowly for the action boys to live with. To compensate, the scientist-become-politician polishes his skills in management, the seemingly universal language of today's world, and by becoming a hard-nosed manager he begins to appear and sound more like the action man, the quick decision-maker and policy-maker that politicians like to deal with. Again, he is usually too late, and he loses rapidly his stature and credibility as a scientist as he achieves a veneer of respectability with the politicians. He winds up with the confidence of neither group, and if he persists in continuing to identify himself with science, he helps discredit it in the public eye. Such people, in reasonably high places, are responsible for a large part of the unrest we're now experiencing in the scientific world. The scientist-become-politician, unless he is a very strong character indeed, succumbs inevitably to the practiced persuasiveness of his professional political bosses and is stuck with aiding and abetting decisions that are often inimical to science. This point is made by none other than Dr. Vannevar Bush, editorializing in the October 1, 1971 issue of SCIENCE, on the danger of overemphasizing the value of the applied phases of science in these times. "There is also a danger that control of funds may occasion injurious dictation to science by laymen. The fact that this is a somewhat subtle matter renders the danger much greater. In applying science it is often correct that a group of laymen should set the general objective . . . . . where men of diverse backgrounds and interest need to meet with scientists and engineers in order to create a program that is sound . . . . . The danger is that this lay participation will go beyond its appropriate function, enter into the methods themselves, and seek to influence the choice of the particular paths to be followed."

Among the scientists-become-politicians, the strong characters recognize this and disjoin themselves, but a host of lesser lights remain to join with the Maleks (Special Assistant to the President for Personnel, SCIENCE, September 24) in finding scientific-political leaders who are not afraid to "shake up" scientific organizations and programs in the name of solving the alleged problem of "bureaucratic inertia." The shaking-up process, unfortunately, is not selective, since the "shakers" know too little about the nuts and bolts of the organizations and programs they shake. There is danger that much good, productive, needed research can fall in the name of better management.

What I'm about to say now has been said before by wiser men about other dilemmas, but it needs saying again. I believe we need not so much more imagination, innovation, better communication, new ideas in management, or new approaches to grapple with the problems at the interface of science and politics, but a return to honesty, candor, and consistency on the part of scientific leadership. I concede it's hard for politicians to be candid and consistent, but there never has been reason for scientists not to be. Scientists who stick to their lasts can help politicians to follow courses that are more likely to provide lasting solutions to the problems they both profess to want to solve. Scientists delude others, and themselves, in "gaming" with crucial issues. The scientist should adhere strictly to the facts he knows and not join in distorting them as in the tendency of some. He should speak out—more than has been his habit and inclination—about what he knows, when occasion demands, but keep his peace when he is ignorant or only marginally smart. It is unnecessary to approach every problem with an open mouth.

I conclude tonight by quoting my friend, a former Assistant Secretary of Agriculture, George L. Mehren, because it jibes with my view that, as bad as things seem to be, we have passed the nadir of the scientists' repute as part of the establishment and that we are on the way back up. In the August, 1971 issue of Food Technology, Dr. Mehren says: "There has been a sustained wave of general nastiness in this country. There are people here who denigrate themselves, their fellow countrymen, and the basic institutions and activities of their nation. Yet the character of this nation has not deteriorated. If anything, its strength of purpose and quality of achievement have been strengthened by this nastiness.

"What has come to be called the disaster lobby appears to be losing its legislative clout. This waning of the doomsday influence is by all standards good. Intellectually, ethically, and aesthetically, the performance of many who call themselves consumer advocates has been ugly. They have often been witless, incompetent, self-righteous, and intolerant of other viewpoints and of democratic resolution.

"These reformers who say that there is but a single truth, that they alone know that single truth, and that they must by any means force it upon all other people have been encountered before and been defeated before.

"There has been much of mindless envy and hatred in what they say and do. The establishment that they attacked seems fortunately now persuaded that perhaps all dignity, wisdom and decency do not reside in those who want to kill the establishment."

I hope Dr. Mehren and I are right and that public confidence in the objectivity, honesty, and good intentions of scientists, as important parts of the establishment, will be restored.